TEACHING INTERMOLECULAR FORCES USING FORENSIC CHEMISTRY

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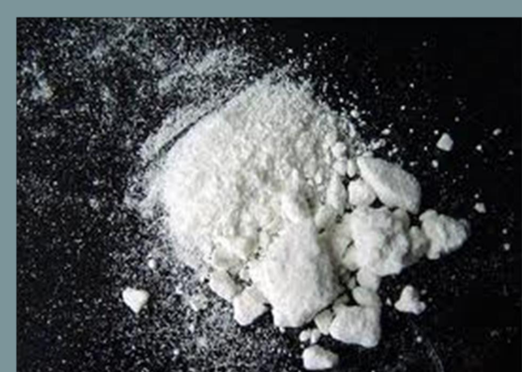
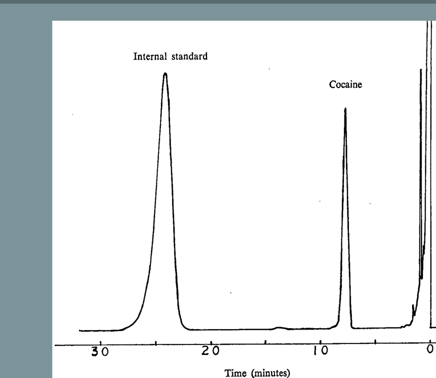
Method of Drug Analysis Used by Forensic Chemists

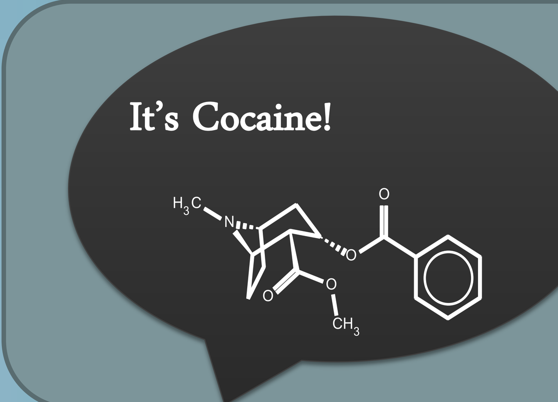


Drug Sample from Crime Scene

Data Acquisition/Instrumentation



Data Analysis



Interpretation/Conclusions

Abstract

The aim of my research was to find an effective way to teach Chemistry students about intermolecular forces. Forensic Chemistry is a growing field that requires instrumental analysis and the most common instrument used in a crime lab is the Gas Chromatography-Mass Spectrometer (GC-MS). I designed a lab that uses a Forensic scenario to teach about the effect of different intermolecular forces on GC-MS results. This lab was modeled after the method of drug identification used in a crime lab, outlined above. It requires students to integrate basic chemical principles and instrumental methods, all inside the context of Forensic Chemistry.

Research Methods

Step 1: Find appropriate compounds

The Forensic scenario calls on the students to correctly identify a drug and two adulterants from a single sample. I needed to find compounds that would show different intermolecular forces clearly.

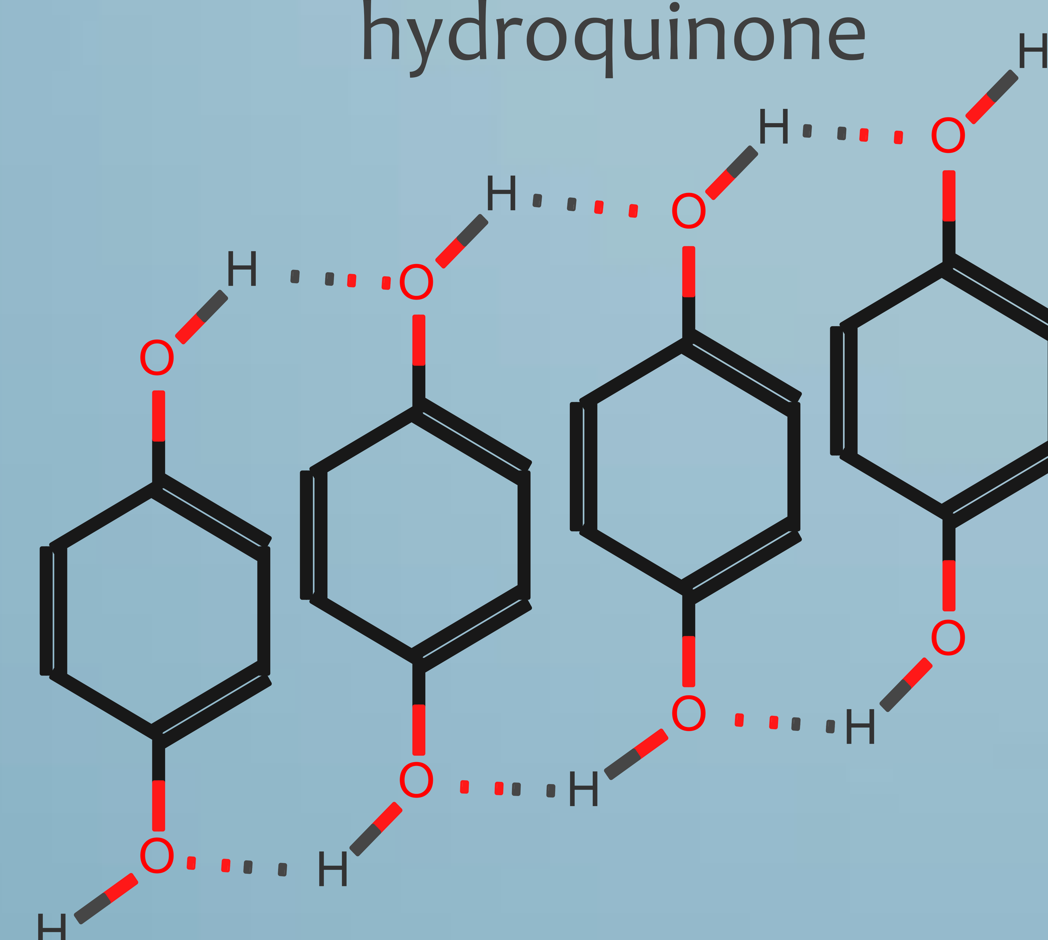
Step 2: Adjust concentration ratio

The concentration of each compound is reflected in the height of the peaks that come out on the GC-MS spectrum. I had to find the concentration ratio that resulted in three peaks of approximately equal heights.

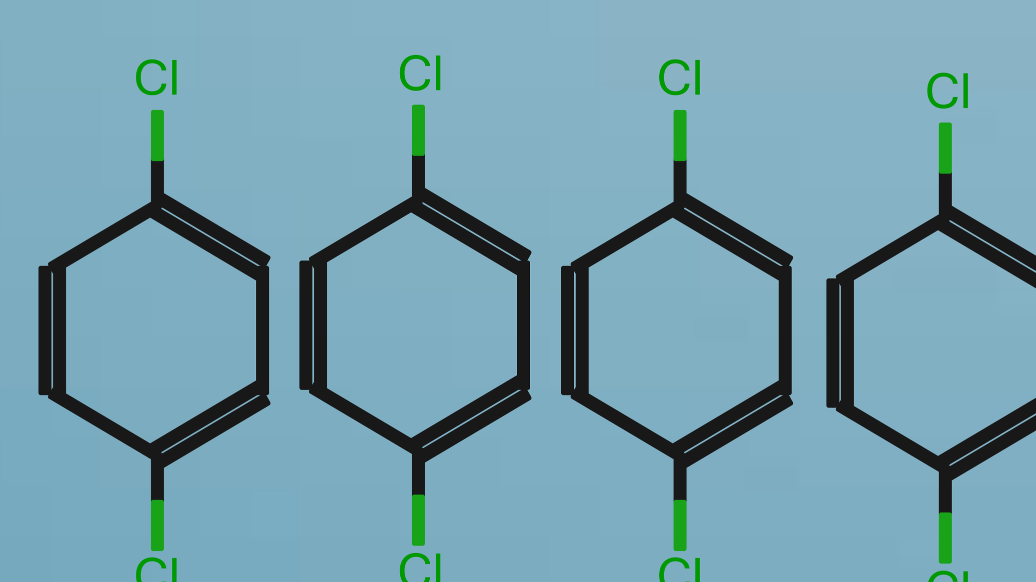
Step 3: Create temperature program

The GC-MS separates compounds by running a sample (mobile phase) through a heated column (stationary phase). Each compound will come out at a different time, called a retention time. I needed to create a temperature program that resulted in three separated peaks.

hydroquinone

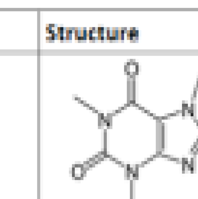
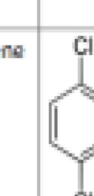


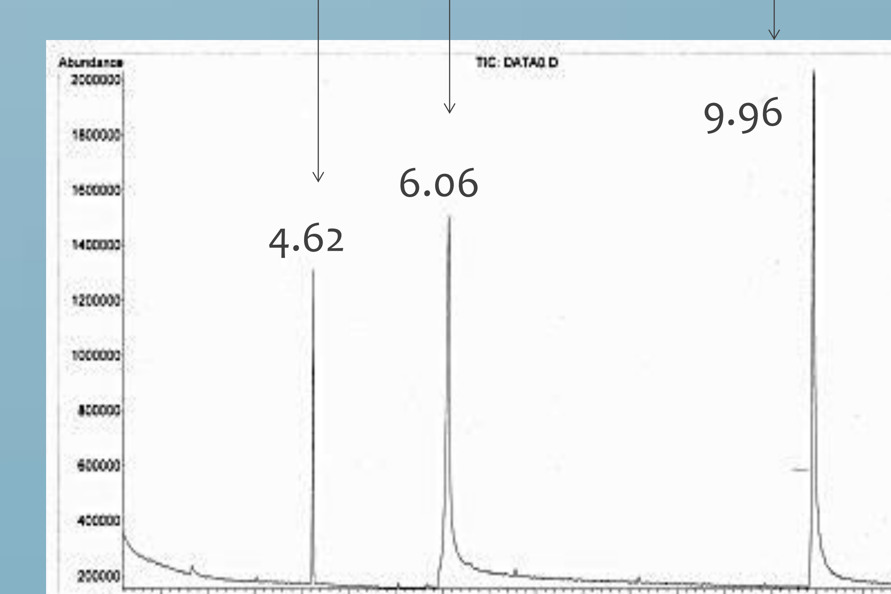
Strong Forces
Vs.
Weak Forces



p-dichlorobenzene

Table of Compounds Used

Name	Structure	Boiling Point	Molecular Weight
Caffeine		178	194
Hydroquinone		287	110
p-Dichlorobenzene		174	147



Strength of Forces

The GC-MS separates compounds based on, among other factors, the strength of their intermolecular forces.

Results

Step 1

I chose caffeine as the mock drug because it is a standard chemical used in GC-MS. After comparing many different compounds, I found that hydroquinone and p-dichlorobenzene were exactly what I needed. They are similar in molecular weight and symmetry, but have different intermolecular forces. So students can compare the forces in a controlled manner.

Step 2

My main problem with concentration was that p-dichlorobenzene because the predominate compound once it was in the column, reducing the other two peaks to small bumps. I finally found that the correct ratio is: 0.05 g p-dichlorobenzene, 0.5 g caffeine, and 1 g hydroquinone. The final spectrum is to the left.

Step 3

In creating a temperature program, there needs to be balance between good peak separation and a short run. The method below has both of those qualities.

Step	Rate (°C/min)	Temperature (°C)	Hold (min)
Start		50	2.5
1	40	150	1
2	20	200	1
3	60	230	1

Total Time = 11 minutes

Conclusion

Through this lab, students will learn about intermolecular forces and have a chance to test their knowledge in a real-life scenario. The parameters I designed can be tailored to fit a General Chemistry, Organic Chemistry, or Intro to Chemistry class.

Bibliography

Bell, S. (2013). Forensic Chemistry. United States of America: Pearson Education, Inc.
Smith, J. G. (2011). Organic Chemistry. New York: McGraw-Hill.